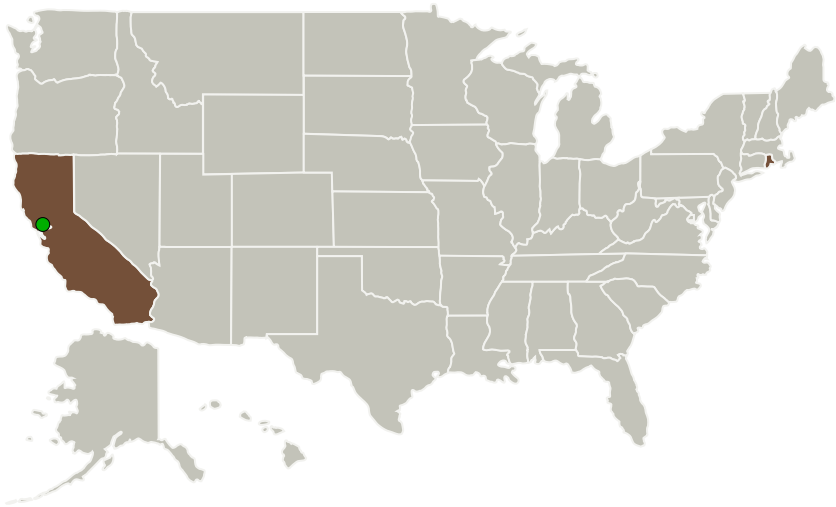
# Integration of Complex Geometry, 3D Woven Preforms via Innovative Stitching Technique, Phase II

Completed Technology Project (2015 - 2017)

## Project Introduction

Thick, 3D woven carbon/phenolic composites offer potential improvement over legacy thermal protection systems (TPS) for re-entry vehicle heat shield applications. However due to the scale and complexity of typical re-entry vehicle structures, it is likely that multiple 3D woven panels would need to laid up to create the overall heat shield, creating potential weak spots at the panel joints. In Phase I T.E.A.M., Inc. addressed the joint issue by developing an innovative stitching process capable of forming mechanically reinforced joints between densely woven, 3D carbon fiber pre-forms up to 3" thick. The Phase I scope included design, model and fabrication of multiple stitched joint specimens with anticipated strength / stiffness properties multiple times higher than baseline, un-stitched joints. In Phase II T.E.A.M. proposed a parallel manufacturing scale-up and D&A/testing effort to mature the MRL/TRL of the developed technology. The high level goals of Phase II are A) To scale the developed stitching process to the size, geometry and repeatability representative of that required for fabrication of net shape re-entry vehicle structure (i.e. ~1.5m base diameter cone + nose cap will be demonstrated), and B) To optimize the stitched joint configuration (i.e. stitch site frequency, orientation and tow size) for performance in a re-entry environment by analytical modeling and mechanical and LHMEL testing of stitched and un-stitched joints using a representative 3D woven carbon/phenolic material system.

## Primary U.S. Work Locations and Key Partners



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## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

T.E.A.M., Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

Carlos Torrez

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| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| T.E.A.M., Inc. | Lead Organization | Industry | Woonsocket, Rhode Island |
| Ames Research Center(ARC) | Supporting Organization | NASA Center | Moffett Field, California |

| Primary U.S. Work Locations | |
|---|---|
| California | Rhode Island |

## Images

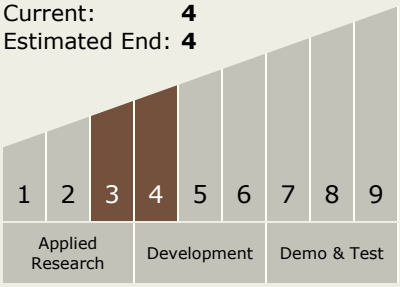
**Briefing Chart Image**
Integration of Complex Geometry, 3D Woven Preforms via Innovative Stitching Technique, Phase II
*(https://techport.nasa.gov/image/127647)*

## Project Management *(cont.)*

**Principal Investigator:**
Aaron Tomich

## Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**




## Technology Areas

**Primary:**

- TX09 Entry, Descent, and Landing
  - TX09.1 Aeroassist and Atmospheric Entry
    - TX09.1.1 Thermal Protection Systems

## Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System